Noise Reduction Efforts for the ALS Infrared Beamlines*

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ALS infrared beamlines experimental setup

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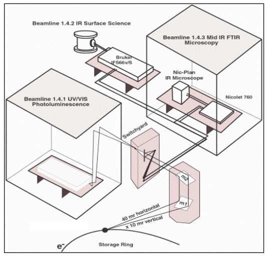


Schematic view of ALS BL1.4
•7 meter from source
•diamond vacuum window for mid-IR transmission
•optical SR beam for alignment

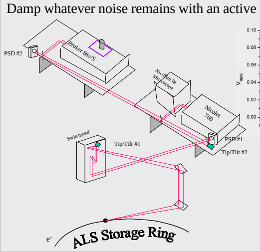
Previous noise reduction efforts

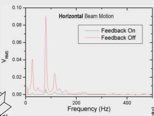
<u>Lower frequency noise is from mechanical vibrations</u>

Mechanically isolated beamline components from environmental noise:

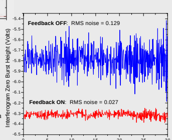
- Mounted the mirror tank to the more stable underlying slab foundation
- Installed a cooling water chiller separate from the main ALS LCW system

Damp whatever noise remains with an active mirror feedback system





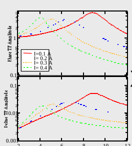
The error signal from one of the four axes with the system off and on.



Time series of FTIR interferogram zero burst maximum with and without active feedback on.

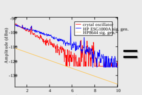
<u>Higher frequency noise is mostly from electron beam energy oscillations at a point of dispersion</u>

Reduced energy oscillations by installing a new master oscillator with lower phase noise in the ALS RF system



Computed beam phase (top) and energy (bottom) transfer functions as a function of beam current

X



Phase noise of master oscillators. The newest one is the bottom trace, as taken from the manual.

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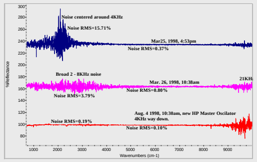


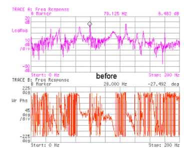
Comparison of the high frequency noise with the old and new digitally synthesized master oscillators.

The quality of infrared microscopy and spectroscopy data collected at synchrotron-based sources is strongly dependent on signal-to-noise. We have successfully identified and suppressed several noise sources affecting the infrared beamlines at the Advanced Light Source, resulting in a significant increase in the quality of FTIR spectra obtained.

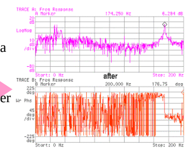
Recent successes in noise reduction

Driven noise transfer functions

A Wilcoxon Research Electromagnetic Shaker was mounted to the M1 and M2 mirror tank. Transfer functions were taken by sweeping the drive frequency from 0-200 Hz and recording the signal from the IR detector.

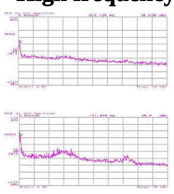


Numerous correlated peaks prompted another look at the mechanical design of the M2 mirror – it was discovered that a tensioning spring had been left out. Replacing this spring and adding motor mounts that further constrained mirror motion immediately quieted the lower frequency resonances.

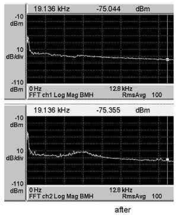


Transfer functions of the IR signal before and after the M2 mechanical modification. A distinct slope in the lower phase plot indicates a vibration correlated to the driving frequency and therefore a significant mechanical oscillation. Many of the mechanical vibration modes were reduced, especially those at 65 Hz, 110 Hz, 128 Hz. The peak that arose at 175 Hz is still under investigation.

High frequency noise filtering



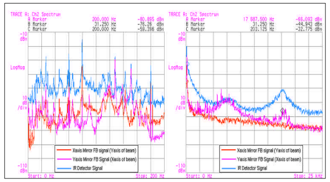
The 18 kHz peak in the bottom trace was seen at the IR beamline and also observed on the x-axis signal of a storage ring beam position monitor. This noise was found to be coming from a DAC output in the storage ring RF phase shifter system. The output of the DAC was filtered by the RF group, almost completely killing the 18 kHz noise.



0-25 kHz spontaneous noise on the first mirror feedback optical detector before and after RF phase shifter DAC filtering. The upper and lower plots represent vertical and horizontal electron beam motion, respectively. Different scopes were used, but the ranges are the same. Notice the substantial reduction in the 18 kHz peak in the bottom-right plot. The broad 7.5 KHz peak is due to synchrotron oscillations and is difficult to suppress.

Sources of spontaneous noise

Noise is created when transverse photon beam oscillations are transformed into intensity variations in the IR signal by one or more apertures in the beamline optics.



Spontaneous noise spectra at the Infrared Beamline 1.4.3, prior to any of the recent improvements.

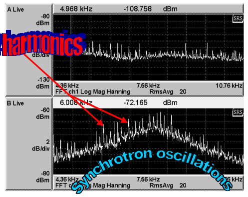
<u>Two main sources of beam motion:</u>

- Mechanical vibrations of beamline components drive lower frequencies
- Electron beam energy oscillations at a point of dispersion (the bend magnet source) drive higher frequencies

Some mysteries remain…

We have always seen 60 Hz harmonics on the spectra at BL 1.4. Are these contributing to the noise at the beamline or just an unimportant nuisance?

- Filtering the output of the RF synthesizer with an active high pass filter did not reduce the 60 Hz lines
- Using an optical link from the RF synthesizer to the klystron had no effect on the 60 Hz lines

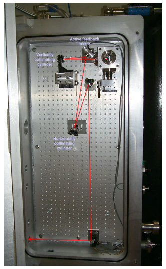


What about the peak due to synchrotron oscillations?

- This comes primarily from phase noise in the master oscillator
- Is our longitudinal feedback system amplifying it? → Experiments with lower feedback gain have had no effect
- Because of its origin, it may be very hard to suppress this peak

Future plans

- **Identify which aperture(s) in the beamline optics are causing the intensity variations; potentially install larger optical elements**
- **Possibly use a feedback system to reduce the master oscillator phase noise**
- **The fast orbit feedback system under development at the ALS should further quiet noise affecting BL 1.4**



The BL 1.4 optical table – each bounce could be an aperture.